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THREE-DIMENSIONAL VISUALIZATION OF DAMAGE IN CELLULAR SOLIDS AND COMPOSITES

by

Stelios Kyriakides and K. Ravi-Chandar

**Final Report for
AFOSR F4960-02-1-0269**

**Defense University Research Instrumentation Program (DURIP)
AFOSR BAA 2001-03**

**Program Mechanics of Materials and Devices
Dr. Les Lee Program Director**

December 2003

**Research Center for Mechanics of Solids, Structures & Materials
WRW 110
The University of Texas at Austin
Austin, TX 78712**

THREE-DIMENSIONAL VISUALIZATION OF DAMAGE IN CELLULAR SOLIDS AND COMPOSITES

by

Stelios Kyriakides and K. Ravi-Chandar

This DURIP grant provided funds (\$105.6k) to purchase a state of the art confocal microscope. Additional funds (\$28k) provided by the University of Texas went to purchase several accessories such a data acquisition system. The new equipment enhance the capability of the laboratories of the Center of Mechanics of Solids, Structures & Materials in micromechanical analyses of materials with microstructures such as foams, composites, ceramics and other materials of interest to the Air Force. The confocal microscope purchased is has a Nikon Digital Eclipse C1 Confocal Scanner coupled with a TE2000U Inverted Microscope both with accessories. The system uses *MetaMorph* for data processing and measurements. The data acquisition system is LabView based and operates in a Dell PC. Following are two examples of ongoing research projects which have benefited from the new facilities.

RESPONSE AND CRUSHING OF FOAMS UNDER UNIAXIAL AND MUTLIAXIAL LOADS

(*Investigator:* S. Kyriakides)

An extensive study of the mechanical open-cell foams is under way. This includes the initial elastic linearly elastic response, the onset of "yielding" and the tracing of an extended load plateau during which the foam progressively crushes. The study involves combined experimental and analytical efforts. The two major requirements for modeling this behavior is accurate characterization of the morphology of the microstructure and measurement of the properties of the base material. The recently acquired confocal microscope plays an important role in both of these tasks. The scanning feature of this microscope coupled with subsequent 3-D rendering of the images enables accurate capturing of the morphology of cells and ligaments. Subsequent processing of the images using *MetaMorph* allows accurate measurements of geometric variables such as length, area and volume. This new capability is

essential for generating representative microstructures of actual foams, a step which gives us unique new capabilities.

CONFOCAL MICROSCOPY IN THE INVESTIGATION OF FRACTURE PHENOMENA

(Investigator: K. Ravi-Chandar)

Our laboratory has optical and atomic force microscopes and access to scanning and transmission electron microscopes for characterization of damage and fracture. However, a major limitation we faced was in the observation and quantitative characterization of surfaces and topographical structures at high resolution in the visual range - magnifications between 10 and 10 and 1000, spatial roughness on the scale from a few microns to a few hundreds of microns. The confocal microscope fills this critical need very well. Our current research dealing with 3D fracture and dynamic fracture in heterogeneous materials benefits greatly from the newly acquired microscope. For example, interpretation of carefully controlled dynamic and quasi-static experiments performed over the past year requires quantitatively accurate measurement of surface topography; this has been facilitated greatly by the confocal microscope. These new results provide the basis for discriminating between these local and non-local fracture criteria for 3D fracture problems.